DEPARTMENT OF THE NAVY
OFFICE OF THE ASSISTANT SECRETARY
(SHIPBUILDING AND LOGISTICS)
WASHINGTON, D.C.

BEST MANUFACTURING PRACTICES

AD-A221 012

REPORT OF SURVEY CONDUCTED AT

LITTON SYSTEMS, INC. GUIDANCE AND CONTROL SYSTEMS DIVISION WOODLAND HILLS, CA

OCTOBER 1985

BMP

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0138

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	Oct 85	BMP Report Oct 85

4. TITLE AND SUBTITLE
Best Manufacturing Practices Report Survey Conducted of Litton Systems, Inc., Guidance and Control Systems Division, Woodland Hills, CA

5. FUNDING NUMBERS

6. AUTHOR(S)
Office of the Assistant Secretary of the Navy (RDA)
Best Manufacturing Practices Program

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Office of the Assistant Secretary of the Navy
(Research, Development & Acquisition)
Product Integrity Directorate
Washington, D.C. 20360-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Same as Number 7.

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
~~No Foreign Distribution~~

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of the Best Manufacturing Practices (BMP) survey conducted at this facility was to identify their best practices, review manufacturing problems, and document the results. The intent is to extend the use of progressive management techniques as well as high technology equipment and processes throughout the U.S. industrial base. The actual exchange of detailed data will be between contractors at their discretion. A company point of contact is listed in the report

The intent of the BMP program is to use this documentation as the initial step in a voluntary technology sharing process among the industry.

14. SUBJECT TERMS	15. NUMBER OF PAGES 17
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	

BEST MANUFACTURING PRACTICES

REVIEW

OCTOBER 1985

LITTON SYSTEMS, INC

GUIDANCE & CONTROL SYSTEMS DIV

WOODLAND HILLS, CA

DEPARTMENT OF THE NAVY

WASHINGTON, DC

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I. INTRODUCTION

A. Scope

The purpose of the Best Manufacturing Practices (BMP) Review conducted at Litton Systems, Inc. was to identify best practices, review manufacturing problems and document the results. The goal is to extend the utilization of high technology equipment and processes in the total spectrum of manufacturing throughout the U.S. Defense Industrial Base, and to reduce cost, shorten delivery time, improve quality and increase industrial readiness. To accomplish this, a team of professional Navy managers and engineers reviewed Litton's Guidance and Control Systems Division to identify the most advanced manufacturing processes and techniques used in that facility. Manufacturing problems that had the potential of being industry wide problems were also reviewed and documented for further investigation in future BMP reviews. Demonstrated industry wide problems will be submitted to the Navy's Electronic Manufacturing Productivity Facility for investigation of alternatives to resolve the problem.

This, the first BMP review, was held at the Woodland Hills, California facility which is engaged primarily in development and low rate initial production of inertial navigation systems. The review was conducted from 8-11 October 1985 by a team of Navy personnel identified on page 2 of this report. Litton's high rate production facilities are located in Salt Lake City, Utah and Grants Pass, Oregon. Both facilities report to the Woodland Hills management. These facilities may be surveyed at a later date.

Based on the results of this review a baseline is being established from which a data base will be developed to track best practices and manufacturing problems for dissemination of technology throughout the U.S. Defense Industrial Base.

B. Review Process

This review was performed under the general survey plan guidelines established by the Office of Naval Acquisition Support. The review concentrated on three major functional areas; management, design engineering and manufacturing. The team observed practices and equipment used in these areas. Litton gave in-depth presentations on each area of review. In some cases the presentation was followed up by individual meetings between Navy team members and Litton personnel for more detailed discussion and review.

The Navy team documented potential best practices which will be investigated and compared with the rest of industry. Manufacturing problems encountered by Litton were also discussed and are documented in this report.

C. BMP REVIEW TEAM

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II. SUMMARY

The Best Manufacturing Practices Survey Team spent considerable time and effort evaluating management, design engineering and manufacturing functions. Areas investigated included the contractors management policies and procedures, design analysis, plant layout, facilities, equipment, tooling, and test equipment, receiving inspection, quality assurance, production engineering, material procurement, material handling, inventory control, manufacturing. technology and vendor selection and control.

The format for the survey consisted primarily of contractor presentations relating to the above areas, along with personal interviews of key contractor personnel, general plant tours and additional tours of specific plant areas of special interest.

Litton discussed their management policy and practices which stress significant amounts of communications across and at all levels of personnel and functions. Managers, vice presidents, etc. are aware of the detailed elements of the problems faced at all levels. Personnel at all levels are offered open access to managers and vice presidents. Litton's entire approach to management is aimed at ensuring an unusually high degree of communication. Something not usually found to this extent elsewhere in the industry. Employees seem motivated and the technique appears to contribute significantly to Litton's capabilities.

Steps have been taken to improve design engineering at Litton. A guideline manual was developed to identify and track design disciplines. Historical data in this manual is used to identify past problems and establish analysis parameters. Computer-aided design and analysis have become a major thrust for Litton. Engineering changes are incorporated early-on, facilitating reaching design maturity and product producibility.

Litton has implemented a policy and practice utilizing a high level of management involvement and attention relative to the daily operations and problems of all projects. Several systems have been developed to monitor the status of programs. Numerous meetings are held on a daily basis to discuss and brief all levels of management including vice presidents regarding all significant problems and the status of all programs. Contrary to what might appear as excessive micro-management, this practice by Litton has resulted in a true "team approach" to solving problems as they arise. An excellent working relationship between the working level and all levels of management is attributable to management's "open door" policy and a very positive attitude at all levels within Litton.

A practice of conducting receiving inspection testing to screen 100% of all incoming electronic components at the piece part level was established by Litton in 1976. The inspection equipment represented a significant capital outlay for Litton and the screening practice is costly, however Litton's large business base and significant reductions in rework at higher level circuit assemblies have resulted in increased profits and improved schedule adherence.

Much of Litton's manufacturing success can be attributed to their attention to detail and improving manufacturing processes and program control. Efforts have been made to get production workers involved in problem solving and production improvements. Collocating management, engineers, and production workers in the same part of the plant is one example of a practice used to establish team involvement which has been highly successful at rapidly identifying and resolving problems.

Most of the manufacturing problems identified by Litton were related to vendor quality control. Even though Litton has taken steps to thoroughly screen vendor parts, they are still experiencing solderability, part marking and part age control problems. These problems were noted and will be reviewed during BMP surveys at other companies for possible industry wide impact.

The Navy team found many positive features at Litton's facility. The most impressive was managements knowledge and involvement in manufacturing operations. Litton's history of delivering high quality products speaks for itself. The BMP survey team believes that other companies would benefit by implementing practices similar to the ones used by Litton.

III. DISCUSSION

A. Management

COMMUNICATION POLICY

Litton is a strong believer in keeping the lines of communication open. The management meets on a frequent basis to discuss matters from program status to specific problem areas. Depending on the type of meeting, it may occur daily, weekly or monthly. Meetings may involve participation by a plant worker all the way to the president.

Litton feels this continued dialogue has resulted in management accessibility, creativity, personal and professional satisfaction and improved quality and productivity. The company appears to be people oriented. The non-union workforce is involved and has an avenue to discuss problems or to recommend improvements to management. This open door policy also helps management to stay informed.

FIRST ARTICLE MASTER SCHEDULING COMMITTEE (FAMSCO

FAMSCO is a developmental scheduling system for the planning and control of the first article of a new program. It may also be used if there is a scheduling problem in a subsequent procurement. FAMSCO establishes goals or key milestones. It gives early warning of schedule problems.

FAMSCO is unique because of the participation by the people who have to do the work. The workers participate in the working level committee, which is one of three committees. The other two committees are at the director level and the senior management (vice president) level.

When a schedule problem gets to the point of impacting delivery, a "red flag" flash form is hand carried to the vice president who is responsible for corrective action. The problem is then addressed at the director level FAMSCO. If not resolved there, it is then taken to the senior management level. FAMSCO for action. FAMSCO has top level management support. The vice presidents depend on FAMSCO for schedule problem visibility and resolution.

FIRST ARTICLE SCHEDULING TECHNIQUE (FAST

FAST is an automated critical path planning and scheduling technique used to project schedule slippage and to determine the impact on delivery. Since it is on-line (interactive), the projection is obtained immediately. FAST takes into account any float that exists in the schedule. If FAST determines that delivery will be impacted, then FAMSCO is used to get back on schedule.

The FAST program was developed at Litton but has been made available to other firms and agencies. By examining the effects of schedule changes on other downstream activities along the critical path, FAST provides a simple and reliable tool for program management.

RELIABILITY IMPROVEMENT WARRANTY (RIW) PROGRAM

The Reliability Improvement Warranty Program appears to be an effective product management strategy for both the government and the contractor. The objectives of the program are to increase the reliability, maintainability and overall product quality by contractually extending the warranty period to five years. This extension in time, as compared to normal early transition to organic, enables the contractor to develop dynamic closed-loop corrective processes and thus effect long-range improvements through this extension in control of the configuration during early years of operational development. In addition, it enables

the customer to defer cost expenditures associated with the establishment of a repair depot until system maturation.

RIW enables the contractor to control the product development and maturation more effectively. It makes the contractor responsible for demonstrating the reliability and maintainability expected of his product. In addition, the contractor gains a knowledge of the product's field performance, which results in its continuous improvement throughout its life cycle. In some cases, the mean time between failures improved by a factor of ten as a direct result of the program. This knowledge is also valuable in the development of future generations of similar equipment.

TRANSITION TO OFF-SITE PRODUCTION

Litton's approach to transfer of production from one facility to another seems worthy of note and perhaps even unique among the industry. They have demonstrated the management techniques and the ability to establish and refine production processes at the Woodland Hills facility. Once they decide to transfer production to one of their high volume facilities, they then overlap production schedules at Woodland Hills and the other manufacturing facilities while production capabilities are being established at that facility. This ability has allowed Litton to successfully transfer from the R&D environment to off-site production with minimal impact and without schedule slippages in 100% of the cases over the last 22 years.

PERFECT TEAMS PROGRAM

Litton's labor efficiency, product quality and schedule performance have shown a marked improvement which correlates to the implementation of the "Perfect Teams" concept, which is very similar to the more popularly known quality circles. The program was introduced at Litton's Salt Lake City facility and has resulted in favorable documented results. Quality has improved due to this concept with corresponding improvements in scrap reduction and better adherence to schedules. All of these improvements result in reduced costs at Litton which yield increased profits and makes Litton more competitive in the market.

Employees at the Salt Lake City plant indicate that the program is well received among the workforce. All employees are involved in the program with 8-10 persons generally making up a team. 103 teams are currently active in the Salt Lake City facility. A major training program was developed to educate both the workforce and management. The concept of using the people working on the production floor to identify and resolve problems has been very successful. Implementation of the

Perfect Teams Program is currently under way at the Grants Pass (Oregon) plant and is being studied at the Woodland Hills facility.

STATE OF THE HEALTH MEETINGS

Most companies within the military electronics community have some system for tracking failures for trend analysis and corrective action. With few exceptions, these systems suffer from lack of timeliness and effectiveness. These systems also invariably suffer from a limited involvement of manufacturing personnel.

Litton's approach, via monthly State of the Health meetings, represents a good approach to the resolution of problems. A State of the Health meeting is a review of each program, its schedule and where it is at that time, what failure trends are evident, actions and responsibilities for correction of those problems, and bad on arrival information. Data is collected and entered into a computer and then analyzed for trends at the production facilities on a daily basis. Problems are identified quickly. Because all test failures are routed to quality manufacturing or test engineering experts prior to rework, there is a high degree of expertise available to properly identify and resolve the problem. When appropriate, individual test technicians or line operators attend the State of the Health meetings.

Corrective action requests are typically initiated within two days of problem identification with a requirement for resolution within ten days. In the event that resolution is not expedient or adequate, the problem may be elevated to the vice president level.

The key elements that lead to the success of Litton's system are; expedient problem identification, in-depth analysis of the problem to the lowest level possible, expedient problem resolution, and total involvement of personnel from the production line all the way to top management.

INTRADIVISION CORPORATE SUPPORTED SEMINARS

A unique approach to dissemination of technical information within all divisions of the corporate structure is utilized at Litton. Key representatives from each division meet on a rotating basis at division site locations to exchange information on new technology, problems, solutions and methodology. These meetings are held quarterly for each of the following disciplines; quality, manufacturing engineering, CAD-CAM and methods and process engineering. The meetings are usually 2-3 days of concentrated technical discussions.

TRAINING PROGRAM

Litton goes beyond contractual requirements in the training of personnel. In 1984, 375 classes were given to employees and customers, totaling 33,691 student hours. The training department has a library of over 500 video tapes and 45 different training manuals covering topics from the fundamentals of inertial navigation to wiring and cabling. They have a complete video recording studio. Video tapes are filmed on site and on location by personnel from the Litton training department.

WORK PERFORMANCE VERIFICATION

Some firms have experienced a problem of people falsely initialing off (or stamping off) an operation without actually having performed the work.

Litton took steps to counter this problem by producing a very short training video tape. This tape, which features the division president as well as its chief counsel, has a very sobering effect. It explains the requirements for using stamps as well as the corporate and personal liability incurred when the stamps are used improperly. The BMP team believes that the video tape is a very simple and effective method of addressing a serious problem.

IN-SYSTEM TESTING

Litton has implemented a highly desirable policy which requires full up in-system testing of nearly all spare assemblies supplied for in-service systems. This is relatively rare among system manufacturers and has been a constant concern regarding adequacy of the logistics support components from other manufacturers.

B. Design Engineering

DESIGN ANALYSIS

A concept of in-process analysis and design analysis has proved to be highly effective and successful at Litton. This concept extends the skills of the design engineer's capabilities in real-time and keeps him in focus. It supports the motto "by design, not by chance" to produce reliable, producible and maintainable equipment. Design analysis provide the design engineer education, motivation, discipline controls, real-time analysis and review, and immediate feedback; all of which drives the designing in of reliability, built-in test, testability, producibility and maintainability into the equipment. Litton's in-process design analysis, review, discipline and control

method have been implemented for nearly a decade and have proven effective in the field with greater mean time between failure and improved testability.

DESIGN GUIDELINE MANUAL

This manual provides Litton with a single source of electrical design requirements, guidelines and checklists related to design disciplines, reliability, producibility, maintainability, built in test, testability, component derating, safety and techniques of design for production. The manual contains a checklist of past problems, standard component parameters to be used for worst case analysis and requirements such as component derating criteria, maximum junction temperatures, numerical detection and isolation effectiveness of built in test or test points. It is now mandatory that this manual be applied to all production programs. Numerous benefits have been derived from using this manual.

CAE DESIGN AND ANALYSIS CONTROLS

While there are potential problems in computer-aided design and analysis, Litton has taken steps to develop more foolproof and aggressive controls. A full time group of design analysis engineers has participated in aggressive training to better equip them to manage CAE design and analysis problems. A controlled library of parameters for digital components has been developed on Daisy CAE stations, which cannot be modified by the user. All new component models for Daisy are prepared by design analysis and tested prior to being included in the standard library. Existing analysis software on Daisy is validated using known manual analyses (fault grading, timing gate array models). Special procedures have been created for the verification of gate arrays. New CAE tools are being developed to provide the designer with the capability to perform special analyses using an integrated data base (parts lists and component failure rates): stress analysis, built in test analysis, circuit testability, etc.

CONFIGURATION CONTROL

The practices applied by Litton for managing engineering design changes have proven very effective. Action requests, engineering change notices, engineering requests, vendor variations and rework authorizations are documented and controlled by a real-time interactive data base system.

ENGINEERING CHANGE POLICY

Unlike other firms, Litton encourages rapid incorporation of engineering changes into the production schedule. Other firms prefer to freeze the design once production starts and to incorporate changes in batches in order to minimize disruptions in their production procurement processes. However, Litton feels that the rate of achieving design maturity, reliability growth, and product producibility is directly related to the quantity and rate of the engineering changes.

While this policy may cause some early disruptions, it is consistent with Litton's objective of delivering a quality product with enhanced reliability.

C. Manufacturing

SUPPLIER QUALITY VERIFICATION PROGRAM

The receiving inspection concept has been implemented through a Supplier Quality Verification Program. In 1976, Litton management came to grips with the component failure rate which was the cause of 70% of the assembly problems. Litton feels that controlling problems at the lowest possible level reduces the risk of adding value to an already defective product.

Supplier quality verification is working. The amount of electrical testing performed far exceeds the amount of testing at other system suppliers. In the microcircuit area, rejections have decreased since 1976 from 6-8% to the 1% level. Assembly first test yields have increased from 60% to 90% over the same time period. Note that 4000 assemblies, containing about 150 parts each, are processed per month.

All materials and components are subject to 100% acceptance tests as described by inspection instructions or the procurement document. The degree of test varies in some cases and is a function of the supplier's and Litton's history. This is a comprehensive program that has resulted in significantly improved measurable results.

The receiving inspection function has been computerized to reduce paperwork. Additional benefits are a reduction in operating personnel and improved flow through the test area.

MANUFACTURING PROCESSES

Litton applies a thorough professional policy to its manufacturing process. They adhere to the procedures that are recommended in DoD 4245.7M, Transition From Development to Production. Litton applies current state-of-the-art techniques and materials to its planning and to the development of its design and product. For example, Litton assigns its manufacturing engineers from the design concept through pilot production and into the resulting day-to-day operations. A manufacturing engineer is assigned and dedicated to the product line as it starts production. Litton uses an internal document, Manufacturing Instruction (MI), at the hands-on level for assembly to instruct and guide the worker in the step-by-step procedures of assembly. The MI includes all of the usual information to assist the worker; i.e., tooling required, test instructions, etc. However, the MI improves on the routine industrial traveler by the use of isometric drawings and exploded sketches at the individual operation level. This helps the assembly person to see the work better as he/she proceeds more efficiently through the test instructions of the traveler which are supplemented by exploded sketches.

PROGRAM CONTROL

Litton uses a schedule oriented production control system which initiates and monitors all operations in the building of a product from kitting through completion. This is aided by check points 25, 20, 15 and 5 days prior to manufacturing start date. Status and location changes are tracked by clocking magnetically encoded work order cards in IBM 3604 data collectors located throughout the factory.

Early morning operations meetings are held to monitor status of programs and to address schedule problems. Various reports are generated to aid in program monitoring and problem identification. The system appears to allow Litton to be right on top of production status.

PLANT LAYOUT

In conjunction with the "team approach", Litton has set up facility layouts in some of their key shop areas such that the foreman, managers and production engineers and workers are all collocated in the same plant area. Again this practice is aimed at, and has achieved, a "team concept" to problem recognition and resolution. Although this technique is used in some segments of U.S. industry, it is not commonly found within the electronics industry. This technique has been identified by Thomas Peters, author of the book "In Search of Excellence" as one of the features of any highly successful organization

COMBINED ENVIRONMENTAL TEST FACILITY

One area which the survey team considered to offer an exceptional capability at Litton is a special test facility. Litton has installed and is fully utilizing a Combined Environmental Test Facility, one of only five similar facilities in the country, to allow simultaneous high altitude, humidity, temperature and vibration testing of components, assemblies and systems in the same test chamber. This type of facility is not necessary for most defense electronics suppliers but does offer Litton a particular advantage over other facilities in precise fault isolation for product lines intended for high altitude applications.

IV. BEST PRACTICES

It was premature to identify any practices as best in the electronics industry since this was the first BMP review. However, the Navy team did identify a number of potential best practices, each of which is listed and discussed in section III.

The most notable practices appeared to be Litton's policy and practice of getting management, engineering and production people all involved in identifying problems, recommending solutions and improving the overall quality and reliability. There is an attitude at Litton that breeds personal satisfaction and thus high quality output. Close attention is given to all programs from the design stage to screening incoming vendor parts, testing sub assemblies, rapidly resolving problems, controlling final assembly and shipping the final product on schedule.

Litton has often worked with the Navy and other companies to find a better way to control quality and reduce technical problems and resulting rework. Often this has meant sharing practices with industry. The BMP team felt that many of Litton's practices will prove to be some of the best in the electronics industry.

V. PROBLEM AREAS

The problem areas discussed below were identified by Litton as worthy of further investigation. More data on these areas will be collected and analyzed during future BMP reviews. Problems identified as having industry wide impact will be forwarded to the Electronic Manufacturing Productivity Facility, China Lake, California for research and resolution. Some problems may lead to the establishment of an industry/government ad hoc group.

COMPONENT SOLDERABILITY

Litton is experiencing component solderability problems which may represent a general problem within the electronics industry. This problem has been addressed by several industry groups such as IPC and EIA. Some successes have been achieved but they have been limited. Litton has basically ceased to attempt getting vendor C/A for solderability problems as the part vendors in most cases do not recognize that there is a problem.

There are two main factors Litton believes that causes this problem: 1. part manufacturers don't recognize a soldering problem; and 2. their lack of experience in metallurgy of soldering. Additional observations worthy of note include: hot solder-dipped tinned dipped parts routinely pass and retain solderability; infrared reflowed platings are very inconsistent in terms of solderability; and there is an inconsistency in Mil Spec requirements (MIL-STD-202/750/883) in terms of solderability requirements. Litton has been forced to use an outside vendor to retin component and semiconductor leads because Litton has been unable to get the major semiconductor suppliers to improve their pretinning quality.

PART MARKING

Integrated circuits are experiencing a general problem with marking permanency/legibility. Since Litton procures such a small portion of the market, the clout to convince the integrated circuit OEM to make a change is small. Therefore, the fix is to remark the parts or improve the marking permanency by sealing with an ultraviolet cured sealer. Of the parts which were rejected, 80% were metal covers.

This problem exists with a number of microcircuit suppliers. The microcircuit suppliers do not admit to having a problem and generally state that Litton is the only customer experiencing a problem. A consolidated Navy/industry effort following accumulation of more data from other contractors will highlight the magnitude of the problem and may help lead to a solution.

BOND PULL TESTS

From time to time, Litton has experienced microcircuits that have failed because of substandard internal wire bonds. Problems are most prevalent in hybrid circuits containing many internal wires. Strict process control by suppliers has been found necessary to maintain consistent wire bond integrity. Litton employs wire bond pull tests on a small sample of each lot of parts received to verify bond strengths; however, this test is destructive, costing Litton the price of the part and the test.

POWER SUPPLY FAILURE RATE

Litton along with most other companies in the industry has experienced a high failure rate of power translators. Litton has elected to do a very thorough parts screening of all components at incoming inspection. Power translators are included and the results have been a significant reduction in power translator failures at later stages of system manufacture.

OBSOLETE PARTS

An industry wide problem also faced by Litton adversely affects their material management systems. The problem stems from the rapid changes in electronic devices and their capabilities. As technology rapidly progresses design problems result. Electronic components (semiconductors) are becoming obsolete so quickly that suppliers drop these devices within a year or two and refuse to manufacture more of them for subsequent orders.

DESC parts qualification program is too slow to keep pace with technology changes. This results in costly and time consuming preparation of waivers to use nonstandard parts (parts substitution) while awaiting DESC certification. Costly redesign can result if DESC disapproves the component. The parts substitution process needs improvement and alternate approaches.

SPECIFICATION WRITING

Failure to incorporate industry (prime contractor) comments when specs are being written is becoming a major problem. Putting vendors in charge of committees to generate specifications leads to parochialism. i.e. Mil Std 883 Para 1.2.1 allows noncompliant parts.

SPECIFICATION TAILORING

Compliance with the spec tree without tailoring is difficult if not impossible. One spec may refer back to numerous other specs that no longer apply. Yet the contractor is obligated to produce to these specs often without any changes.

The Navy has recently established an acquisition stream line hotline (1-800-NAV-SPEC) that will address requirements and spec tailoring. This effort is designed to provide for identification and relief of unrealistic spec requirements.

AGE CONTROL OF VENDOR PARTS

Vendors are producing parts and storing them on the shelf for several years. When the part is delivered to a prime and found defective, the vendor is no longer producing the part and refuses to replace it. This is becoming a problem for Litton.

PIND TESTING

Vendors refuse to accept returned parts found defective during PIND testing. Defective parts are not replaced by vendors for those that are not class S parts. Current non-S class specs don't require this test, but it helps reduce defects in Litton products.

IN-SERVICE FAILURE/RELIABILITY FEEDBACK

There is a need for better feedback on in-service failures and reliability. Other than on receipt failures (which are approximately 1% of the units shipped) and RIW products, there is little or no feedback from the field. Litton doesn't know what is happening to the product they produced. Information on in-service failures would provide the contractor knowledge to make improvements on future deliveries to prevent more failures.

VI. CONCLUSIONS

Based on the many discussions with senior Litton managers, the Navy BMP team was favorably impressed by their grasp of detail. The team observed that managers at all levels of the organization, including the president, were intimately aware of the details of the operations under their control. Litton's entire approach to management is aimed at ensuring an unusually high degree of communications and employee involvement. Employees are well motivated. Litton's management philosophy appears to contribute significantly to their overall performance.

The conclusions drawn by the survey team in the manufacturing area are that, while Litton has an excellent manufacturing facility, most of the manufacturing equipment and processes are very similar to those present at most other large defense electronics companies. However, the team noted that Litton has maintained a history of timely deliveries of high quality products along with an excellent 22 year record of successful transition from development to production. Those areas which the team believes contribute significantly to Litton's success, and ones which should be strongly considered for incorporation by other similar defense and industry contractors, are discussed in section III.

Many of the manufacturing problems identified by Litton and discussed in section V appear to have industry wide impact. These problems will be investigated in future BMP surveys. Those having industry wide application will be forwarded to the Electronic Manufacturing Productivity Facility in China Lake, California for detailed research and development of solutions.